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UNITED STATES PATENT APPLICATION FOR
DYNAMICALLY BALANCING LOAD FOR SERVERS

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DYNAMICALLY BALANCING LOAD FOR SERVERS TECHNICAL FIELD

Embodiments of the present invention relate to the field of computer networks. Specifically, embodiments of the present invention relate to
5 dynamically balancing load for servers.

BACKGROUND ART

Each year, traffic over computer networks such as the Internet gets heavier. Typically, rather than having a single server handle all requests
10 for similar information, multiple servers are used. For example, a web site may have many servers that are capable of servicing incoming requests. At essentially one point in time, there may be hundreds of users making requests to the web site. A front-end server distributes those requests among the servers as best as it can. However, conventionally, the
15 distribution of requests is not always efficient.

The front-end server, which may be referred to as a load balancer, can use one of several common techniques to balance the load among the back-end servers. The simplest technique is round robin. A round robin
20 system simply rotates the requests to the back-end servers with each back-end server getting one request per rotation. Another common load balancing technique is to assign the request to the back-end servers randomly. Over the long haul, each back-end server should receive an equal number of requests. Still another technique is to assign a number to
25 each of "N" servers and forward the request to a server by determining a

number between 1 and N for each request. The request is then forwarded to the back-end server whose number matches the request number. Unfortunately, each of these techniques suffers in that imbalances in load can occur for a variety of reasons.

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A second problem with conventional load balancing is that one of the back-end servers can go down. The front-end server sometimes does not recognize this, which results in a request being forwarded to a server that is unable to handle the request. This typically results in an error message and a frustrated requestor. For example, the request may witness the all too common error message that information is not available. If the user tries to get the information again the problem may go away simply because by chance the request is forwarded to a functioning server this time. However, the user has wasted time and raised his/her frustration level. It is also possible that the error is only logged locally, and the user's browser sits waiting for a response that never arrives.

Thus, one problem with conventional load balancing is that the load becomes imbalanced between the servers. Another problem with some conventional load balancing techniques is that they fail to recognize when a server has gone down.

DISCLOSURE OF THE INVENTION

The present invention pertains to a method and system of dynamically balancing load for servers. In one embodiment of the present invention, certain acts are performed to dynamically discover servers and
5 balance load to the servers. Included in those acts are monitoring for servers that are able to respond to requests directed at the system. After discovery of a server, a performance metric is obtained for the discovered server. The performance metric for the discovered server is stored in a table. When a request is received, the request is routed to a selected
10 server in the system of servers based on the performance metric, wherein the system of servers comprises the discovered servers.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

Figure 1 illustrates a system that balances a load between servers, in accordance with an embodiment of the present invention.

Figure 2 is a flowchart illustrating a process of discovering and analyzing new servers, in accordance with an embodiment of the present invention.

Figure 3 is a flowchart illustrating a process of balancing a load between servers, in accordance with an embodiment of the present invention.

Figure 4 is an exemplary table of performance metrics, in accordance with an embodiment of the present invention.

Figure 5 is an exemplary computer platform, upon which embodiments of the present invention may be practiced.

DETAILED DESCRIPTION OF THE INVENTION

In the following detailed description of embodiments of the present invention, a method and system of dynamically balancing load for servers, numerous specific details are set forth in order to provide a thorough
5 understanding of the present invention. However, embodiments of the present invention may be practiced without these specific details or by using alternative elements or methods. In other instances well known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the present invention.

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Embodiments of the present invention provide a method and system of balancing load that dynamically discover when servers first become available and determine a performance metric for the servers at that time. Thus, methods and systems in accordance with the present
15 invention are not limited to only routing requests to servers that a load-balancing agents was informed about by, for example, a system administrator. The performance metric for each discovered server may be stored in a table. A stress factor may also be calculated for each server, based on server load and the performance metric. Requests to the servers
20 may be balanced based on the stress factor. Embodiments of the present invention provide a method and system of balancing load that avoids imbalances experienced by conventional load balancing techniques.

Figure 1 depicts a system 150 that dynamically discovers servers
25 and dynamically balances a load between the servers, in accordance with

an embodiment of the present invention. The system 150 comprises two front-end web servers 160a and 160b that each has a load-balancing agent 170a, 170b. The system 150 also comprises a number of back-end servers 180a, 180b, 180c that are able to service requests to the system 150. For example, the requests may be for information stored on a back-end web server 180a, 180b, 180c or a database that is accessible by a back-end web server 180a, 180b, 180c. The present invention is well suited to using any number of front-end web servers 160a, 160b and any number of back-end servers 180a, 180b, 180c. The system 150 comprises a portal 155 to allow access to the web site, for example. In this example, the system 150 is a web site, although the present invention is not limited to balancing load at a web site. For example, the load may be balanced between computing devices in a LAN (local area network), WAN (wide area network), etc.

15 In this embodiment, at least one of the load-balancing agents 170a dynamically discovers new servers 180n. It is not required that server discovery is performed by the load balancing agent 170a, 170b; another component may perform the server discover and inform the load balancing agents 170a, 170b. The dynamic server discovery logic 185 is used to discover new servers 180n that are capable of servicing requests to the system 150. In Figure 1, one of the load-balancing agents 170a is depicted in the process of discovering a new server 180n. Upon discovery, load-balancing agent 170a may inform load-balancing agent 170b of the new server 180n. Alternatively, each load balancing agent 170a, 170b may perform server discovery independently. Advantageously, an

administrator is not required to provide the load-balancing agent 170a, 170b with a configuration file identifying the new server.

In one embodiment, dynamic server discovery is performed using UDDI (Universal Description, Discovery, and Integration). In another embodiment, CORBA (Common Object Request Broker Architecture) is used to dynamically discover new servers. However, the present invention is not limited to using UDDI or CORBA for discovering new servers 180n. The new servers 180n that are discovered are not servers that were once a part of the system 150, but that went offline for some reason. Rather, they are servers that were not previously a part of the system 150. Thus, the new servers are servers of which the load-balancing agent 170a, 170b was previously unaware. However, the load-balancing agent 170a, 170b is capable of determining that a server that went offline has again become capable of handing requests.

An example of new servers coming online, for illustrative purposes, is a company bringing more servers online during a period in which the number of requests is expected to increase, such as holidays.

Embodiments of the present invention dynamically discover the new servers without requiring an administrator to send a configuration file to the agent. This is in contrast to typical conventional systems that require a system administrator to make the agent aware of the new servers by sending a new configuration file. Moreover, in contrast to some

conventional systems, the new servers do not need to be rebooted in embodiments of the present invention.

Each load-balancing agent 170a, 170b maintains a table 200a, 200b
5 that is used in determining to which server 180a, 180b, 180c to route an incoming request. The table 200a, 200b may comprise a performance metric and a stress factor for each server 180a, 180b, 180c. The performance metric may be response time to a request that is determined at the time a new server 180n is discovered. Thus, the table 200a, 200b is
10 modified each time a new server 180n is discovered. However, the present invention is not limited to modifying the table 200a, 200b only when a new server 180n is discovered. In one embodiment, the table 200a, 200b is modified periodically, based on an analysis performed by the load-balancing agent 170a, 170b. Moreover, the table 200a, 200b may include
15 information for servers that the load-balancing agent was informed of by, for example, a system administrator. Thus, the table 200a, 200b is not limited to information about servers that the load-balancing agent discovered itself.

20 The table 200a, 200b may also contain load information for each server 180a, 180b, 180c. The load-balancing agent 170a, 170b is able to query the servers 180a, 180b, 180c for load information, in one embodiment of the present invention. The load-balancing agents 170a, 170b are depicted with load query logic 188a, 188b to perform this

function. The load information may be used to determine a stress factor for each server 180a, 180b, 180c, as discussed below.

Figure 2 is an exemplary performance metric table 200, in accordance with an embodiment of the present invention. There is a server identifier column 210, an initial response time column 220, a load column 230, and a stress factor column 240. The stress factor may be calculated according to Equations 1-3 below. However, the present invention is not limited to calculating the stress factor via Equations 1-3. The initial response time describes the response when the server is first discovered. Hence, it is a measure of unloaded response time. The performance metrics in the table 200 of Figure 2 are exemplary and many other metrics may be used within the scope of the present invention.

Figure 3 illustrates steps in a process 300 of dynamic server discovery and performance evaluation, in accordance with an embodiment of the present invention. Steps of process 300 may be stored as instructions in a computer readable medium. The instructions may be executed by a general-purpose computer, such as computer system 100 of Figure 5, in order to implement the process 300. Process 300 is an ongoing process that is active while the load-balancing agent is routing requests to the servers, although the routing is not depicted in process 300. In step 310, a load balancing agent monitors for new servers that were previously not part of the system. The monitoring may be performed at any suitable time and with any suitable periodicity. When a new server is discovered,

steps 320, 330, and 340 are performed in which information about the new server is collected and stored. Then, the load-balancing agent again monitors for new servers.

5 More specifically, process 300 goes to step 320 if step 315 indicates a new server is discovered. In step 320, the load-balancing agent determines a performance metric for the server as that server is discovered. The performance metric is a response time to a request, in one embodiment. For example, while the new system is not yet processing
10 requests, the load-balancing agent may send a “Hello” to the newly discovered server. In one embodiment, the load-balancing agent sends a database query to the new server.

At step 330 the present embodiment makes a determination of a
15 stress factor that may be used in a request routing decision. The determination may be made in a number of ways; the exact formula is not critical. To determine the stress factor, first the load-balancing agent may first determine the average load for the servers in the system. The load-balancing agent performs a query of load information from each server
20 and calculates average load according to Equation 1.

$$\text{Equation 1: Ave_Load} = (\text{Serv1_Load} + \text{Serv2_Load} + \dots \text{ServN_Load}) / N$$

It is not required that the load query be performed with each
25 request. For example, the load query may be performed periodically by the

load-balancing agent at any convenient interval. The load for each server is stored in the performance metric table.

The load-balancing agent of the present embodiment then may
 5 determine the average response for servers in the system according to the formula in Equation 2. In Equation 2, Init_Resp_ServN refers to the initial response of a given server that was determined by the load-balancing agent when that server was first discovered.

10 Equation 2:
$$\text{Ave_Resp} = (\text{Init_Resp_Serv1} + \text{Init_Resp_Serv2} + \dots + \text{Init_Resp_ServN}) / N$$

From Equations 1 and 2, the load balancing agent may determine the stress factor for a given server in accordance with Equation 3, where
 15 ServN_Load and Init_Resp_ServN are obtainable from the performance metric table, Ave_Load is calculated as per Equation 1, and Ave_Resp is calculated per Equation 2.

Equation 3:
$$\text{Stress_N} = ((\text{ServN_Load} / \text{Ave_Load}) + (\text{Init_Resp_ServN} / \text{Ave_Resp})) * 0.5$$

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The load-balancing agent may calculate a stress factor for each server in the system and route the request to the server with the lowest stress factor. It is possible that two or more servers have a stress factor
 25 that is either the same or so close to one another that for the present

discussion the stress factor may be considered essentially the same. In either of these cases, the load balancing agent may decide between the servers by dynamically running the response query to re-order the servers. Thus, the initial response (e.g., Init_Resp_ServN) is replaced by a
5 current response.

At step 340 the present embodiment stores the performance metric and the stress factor in a table. The table may be used in the process 400 of Figure 4 to make a request routing decision. The process 300 then
10 returns to step 310 of monitoring for new servers.

Figure 4 illustrates steps in a process 400 of dynamic load balancing, in accordance with an embodiment of the present invention. Steps of process 400 may be stored as instructions in a computer readable
15 medium. The instructions may be executed by a general-purpose computer, such as computer system 100 of Figure 5, in order to implement the process 400. Process 300 of Figure 3 and process 400 of Figure 4 may execute concurrently.

20 At step 410, the present embodiment accesses a request that is serviceable by at least one of the servers. For example, a request may be received by a front-end web server.

Next, at step 420 the present embodiment routes the request to a
25 server as determined by accessing the stress factor for the discovered

servers. For example, the load-balancing agent accesses a table to find the server currently having the lowest stress factor. The servers from which the load-balancing agent selects from are not limited to those servers that the agent actively discovered itself.

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In step 430, the present embodiment routes the request to the server that was determined to have the lowest stress factor. The process 400 repeats itself as new requests are received in step 410. As process 300 of Figure 3 may be executing concurrently with process 400, the number of
10 servers that are available changes as servers are dynamically discovered. Moreover, the load-balancing agent does not passively wait to be informed about new servers, but actively seeks out new servers. Furthermore, the values in the table may also change dynamically as the load balancing agent performs new load queries and discovers more servers.

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Figure 5 illustrates circuitry of an exemplary computer system 100, which may form a platform for embodiments of the present invention. Computer system 100 includes an address/data bus 99 for communicating information, a central processor 101 coupled with the bus for processing
20 information and instructions, a volatile memory 102 (e.g., random access memory RAM) coupled with the bus 99 for storing information and instructions for the central processor 101 and a non-volatile memory 103 (e.g., read only memory ROM) coupled with the bus 99 for storing static information and instructions for the processor 101. Computer system 100
25 also includes an optional data storage device 104 (e.g., a magnetic or optical

disk and disk drive) coupled with the bus 99 for storing information and instructions.

With reference still to Figure 5, computer system also includes an
5 alphanumeric input device 106 including alphanumeric and function keys
coupled to bus 99 for communicating information and command selections
to central processor unit 101. Computer system also includes a cursor
control device 107 coupled to bus 99 for communicating user input
information and command selections to central processor unit 101.
10 Computer system of the present embodiment also includes a display
device 105 coupled to bus 99 for displaying information. A signal
input/output communication device 108 coupled to bus 99 provides
communication with external devices.

15 While the present invention has been described in particular
embodiments, it should be appreciated that the present invention should
not be construed as limited by such embodiments, but rather construed
according to the below claims.